Technology Development & Deployment: A History of Successful Investments

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(EM-20)

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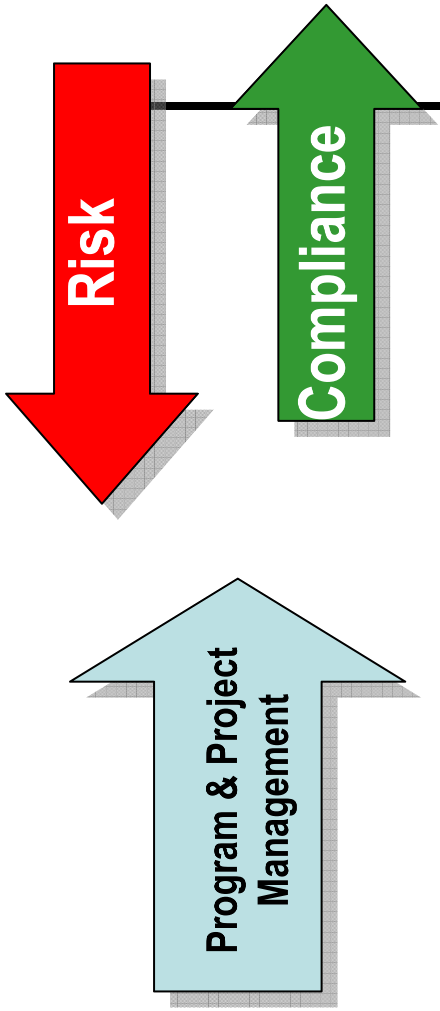
Our priorities . . .

#1 Priority: Safety



Reduce risk while maximizing regulatory compliance

- Construct **waste treatment facilities** to clean up tank wastes
- Consolidate and prepare for disposal of **surplus plutonium** and **spent nuclear fuel**
- Continue disposal of **transuranic and low-level waste**
- Continue **soil and groundwater remediation**
- Continue decontamination and decommissioning of **unneeded facilities**

Strengthen program and project management

- Implement **National Academy of Public Administration** recommendations
- Independently verify **project baselines** – scope, cost, schedules
- Strive for **"Best in Class"** capability
- Assure effective identification and **management of risk**
- Implement more effective **acquisition process**
- Develop and deploy needed **technologies**
- Focus on **project execution** through enhanced use of
  - Earned Value Management Systems and
  - Ongoing performance reviews by project and senior EM managers

Engineering and Technology Program

Mission

- To Identify Vulnerabilities and to Reduce the Technical Risk and Uncertainty of EM Programs and Projects

Vision

- Engineering and technology initiatives will provide the engineering foundation, technical assistance, new approaches, and new technologies that contribute to significant reductions in risk (technology, environmental, safety, and health), cost, and schedule for completion of the EM mission.

EM Office of Engineering and Technology

Mark A. Gilbertson
Deputy Assistant Secretary Engineering and Technology

Dr. Steve Krahn
Director

Office of Waste Processing

Dr. Vince Adams
Director

Groundwater & Soil Remediation Office

Yvette Collazo
Director

D&D and Facility Engineering Office

Established to Reduce Technical Risk and Uncertainty in the EM Program

Functions

- Develop policy and guidance
- Assess projects and programs through technical reviews and oversight
- Provide technical assistance and support to the field and other Headquarters offices
- Manage the EM Technology, Development and Deployment Program

Strategic Planning for Engineering and Technology Program Activities

- Strategic Planning Approach
  - Implement Roadmap Initiatives
  - Select Critical, High-Risk, High-Payoff Projects
  - Conduct Technical Workshops and Exchanges
  - Complete External Technical Reviews
  - Review Risk Management Plans
  - Complete Technology Readiness Assessments

- Collaboration with National Laboratories, Private Sector, and Universities for innovative technologies and technical exchanges

- Work with Federal Project Directors

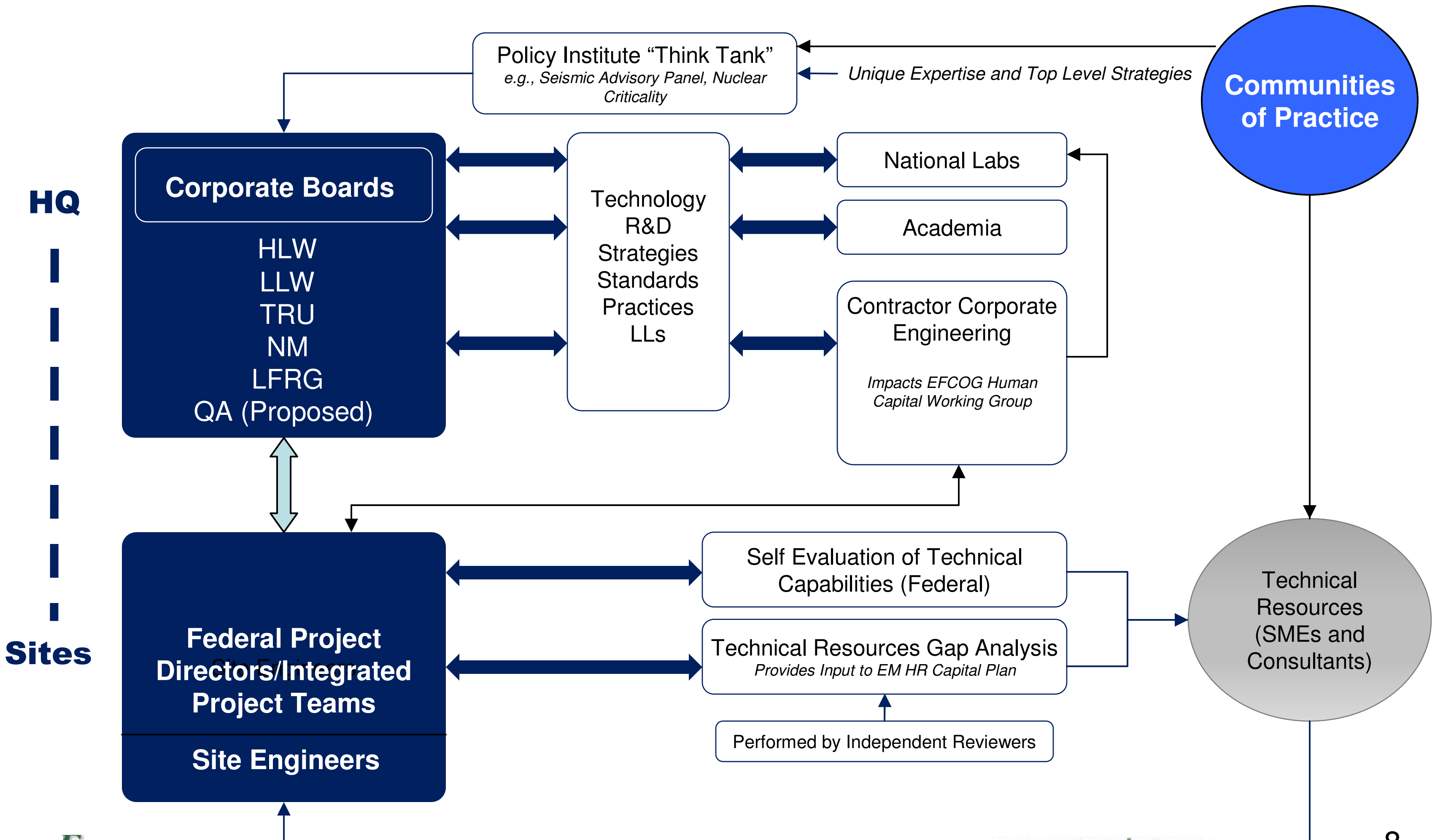
Engineering & Technology FY2008 Management Initiatives

- Best-in-Class Program
- Technology Readiness Assessment Policy and Guidance
- Secretary's (TEAM) Transformational Energy Action Management Initiative
- Real Property Management Process

Best-In-Class Engineering and Technology Initiative

- Current Implementation Activities include:
  - Integrated Project Team (IPT) Self Assessment – Technical Capabilities
  - IPT External Assessment – Technical Capabilities
    - Results from self and external assessments will feed into EM Human Capital Management Plan and Technical Qualifications Program
  - Enhance technical capability at Headquarters through use of national laboratory intergovernmental personnel act assignments (IPA)
  - Explore other human resource options, including Professional Development Corps, Florida International University Intern Program, International secondments, Vanderbilt training program, NRC grant program, etc.
  - Benchmarking [Federal and private organizations; International – United Kingdom Nuclear Decommissioning Authority]
  - Establishment of EM Corporate Boards [new Boards include HLW and QA]
  - Finalization of EM Cleanup Technology Roadmap and strengthening of associated Communities of Practice
  - Continued utilization of External Technical Reviews and Technology Readiness Assessments

Striving for EM Program Engineering and Technology Excellence



Technology Development and Deployment

- Much progress made in Environmental Management cleanup mission, e.g., completion at Fernald and Rocky Flats; more expected over next few years
- Major uncertainties/risks across the Complex must be addressed through innovative technologies and approaches
- Technologies have been inserted to reduce risk through accelerated schedules, cost savings, reduction in worker risk, and solving intractable problems
- Solutions have made a difference in waste processing, soils and groundwater treatment, and deactivation and decommissioning
- Presenting some examples of success over last 5 years

Advanced Remediation Technologies (ART)

- Congressional line-item of $10M in 2005
- DOE issued competitive solicitation for Advanced Remediation Technologies
- Awarded 12 Phase I contracts in 2006 to industry for proof-of-principle investigation of a variety of technologies to address high-risk waste-processing and subsurface remediation issues
- Awarded 5 Phase II contracts in 2007 to perform large-scale demonstrations of the innovative technologies at the Hanford and Savannah River Sites

ART: Cold Crucible Induction Melter

Challenge
Joule-heated melter at the Savannah River Defense Waste Processing Facility (DWPF) may not vitrify waste to meet the Site Treatment Plan date of 2028, due to higher volumes of sludge than originally predicted

Solution
The Cold Crucible Induction Melter (CCIM) can accommodate higher waste loading and throughput

Accomplishments
Completed testing on Idaho, Hanford, Savannah River, and Marcoule simulants

Demonstrated high waste loading on Savannah River-type waste at Radon Institute in Russia

Completed pre-conceptual design study for a Defense Waste Processing Facility retrofit

ART Phase II initiated to extend testing with representative conditions and conduct initial engineering tasks

Potential Impact
Cold Crucible Induction Melter technology advantages:

- Increased waste loading (50+ vs 34-38 wt%)
- Higher waste throughput and melt rate
- Possible extended melter service life
- Higher tolerance for noble metals

Cold Crucible Induction Melter may result in life-cycle cost and schedule reduction, while meeting regulatory agreements and closure dates

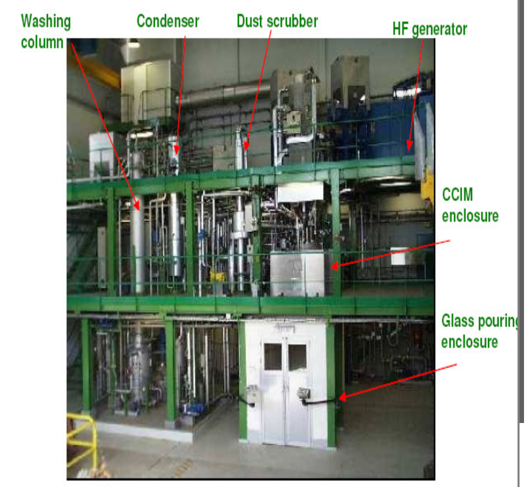


Figure 1: General view of the CCIM demonstration platform – CEA Marcoule

ART: Fluidized Bed Steam Reforming

Challenge

The Hanford Waste Treatment Plant (WTP) will separate high-level waste (HLW) into a small-volume HLW and large-volume low-activity waste (LAW) fractions, which cannot be treated in time to meet proposed schedule. Supplemental treatment is necessary.

The WTP recycle stream, planned for treatment at the Effluent Treatment Facility (ETF), must be pretreated, because concentrations of some constituents are problematic

Solution

THOR Treatment Technologies, LLC proprietary Fluidized Bed Steam Reforming (FBSR) technology could be used for low activity waste supplemental treatment and WTP recycle treatment

Accomplishments

Completed ART Phase I feasibility study for Hanford waste

ART Phase II pilot-scale real-waste testing to start in April

Potential Impact

Fluidized Bed Steam Reforming may reduce overall Waste Treatment Plant mission length by up to 30% at a lower cost than other options and could eliminate all issues with Effluent Treatment Facility recycle

ART: Near-Tank Cesium Removal

Challenge
Current Tri-Party Agreement milestones require that all high-level waste (HLW) be removed from the Single Shell Tanks (SST) by 2018, but Double Shell Tank (DST) space is not available

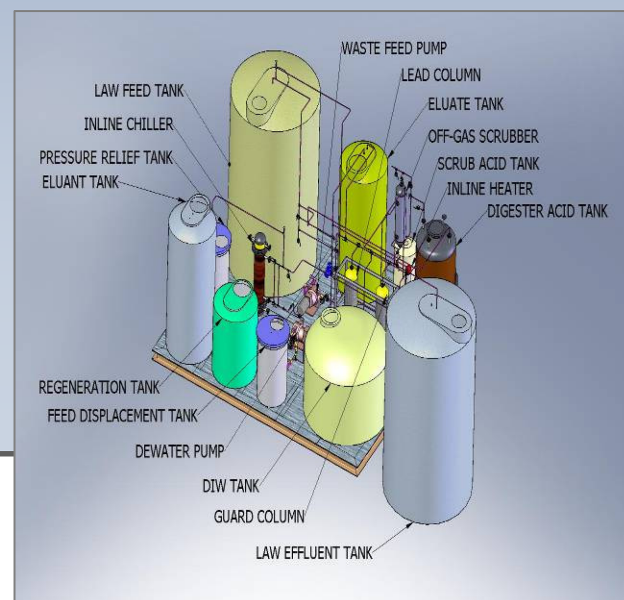
Solution
Near-Tank Cesium Removal (NTCR): If cesium can be removed at the Double Shell Tanks, the low activity waste (LAW) stream could go directly to supplemental treatment, allowing Single Shell Tanks to be emptied into Double Shell Tanks

Accomplishments
Completed system description, risk review, preliminary field design, and cost and schedule estimates for the ART Phase II demonstration unit

Completed proof of principle experiments to test resin destruction and dissolution in nitric acid

Potential Impact
Near-Tank Cesium Removal could accelerate WTP Low activity waste start date by up to 6 years and will supply feed to Low activity waste supplemental treatment

Early Double Shell Tank waste processing will allow Single Shell Tank retrieval to proceed, will demonstrate progress on tank waste treatment, and will accelerate Tank Farm Closure



ART: Continuous Sludge Leaching

Challenge

Removal of large quantities of aluminum from high-level waste (HLW) tank sludge at both Savannah River and Hanford could significantly reduce the volume of high-level waste to be vitrified, reducing the number of glass canisters to be produced, and enabling the planned high-level waste treatment schedules to be met

Solution

Continuous Sludge Leaching (CSL) can remove boehmite aluminum from the high-level waste sludge

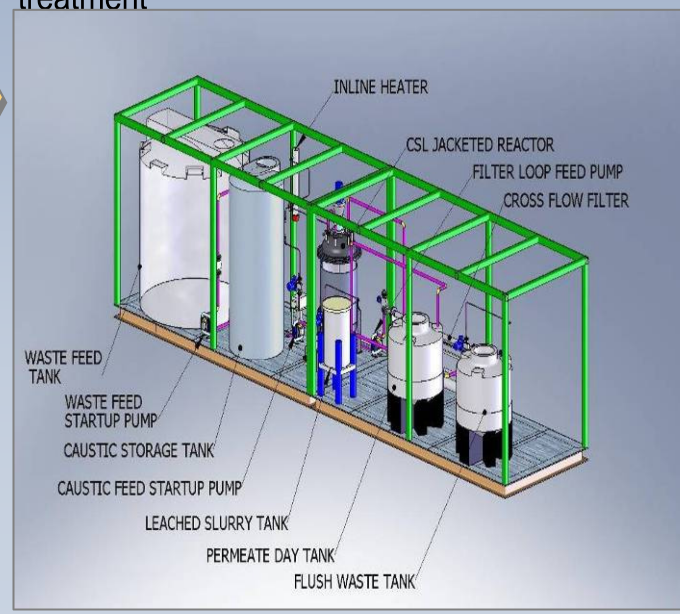
Accomplishments

ART Phase I evaluated feasibility of Continuous Sludge Leaching to remove boehmite from high-level waste tank sludge

ART Phase II lab-scale testing will begin in Spring 2008

Potential Impact

Continuous Sludge Leaching can dramatically reduce the number of high-level waste canisters produced at both Savannah River (up to 35%) and Hanford (up to 55%) by removing aluminum from HLW tank sludge, thus potentially saving billions of dollars in life-cycle cost for HLW treatment



Pilot Scale Facility

ART: Enhanced Anaerobic Reductive Precipitation/Dechlorination

Challenge

No technologies are currently available to treat technetium-99 (Tc-99) contaminated groundwater *in situ*, yet Tc-99 is a high risk because it is long-lived and mobile in the environment

Solution

Identify and optimize commercially available in-situ remediation treatment technology to treat metals, radionuclides, and organics in groundwater

Accomplishments

Enhanced Reductive Precipitation/Dechlorination (EARP/D) has been used at 190 sites, including 21 federal government sites; lab- and pilot-scale tests have shown that Enhanced Reductive Precipitation/Dechlorination can be applied to technetium-99 and other key radionuclides

ART Phase II will demonstrate an in situ field-scale application at Hanford or Savannah River at an area where technetium-99 is present in the groundwater

Potential Impact

Enhanced Reductive Precipitation/Dechlorination may provide a solution for *in situ* treatment of radionuclides in groundwater where no current solution exists, thus significantly reducing risk to human health and the environment

Mobile Batch Injection Trailer

Columbia River Projects

- HR 2419, Energy and Water Development Appropriations Act passed by Congress in 2006 where conferees expressed concern about preventing contaminants from reaching the Columbia River
- Allocated $10M to analyze contaminant migration to the river and to introduce new technologies to solve contaminant migration issues
- 12 Projects awarded to Pacific Northwest National Laboratory and Fluor after independent review of proposals
- 11 projects address contamination in the 100 Areas near the river (uranium, chromium, and strontium) and one in the 200 Areas (carbon tetrachloride)

Columbia River Projects: Remediation of Hexavalent Chromium in Groundwater

Challenge

Migration of groundwater contaminated with hexavalent chromium entering the Columbia River at the Hanford Site; high environmental risk

Solution

Understand where chromium is present as a source and how it moves through soils above the water table; test a variety of technologies to treat groundwater using a systems approach

Accomplishments

Lab and field studies improve understanding of fate and transport of chromium in soils above the water table and where chromium may be present as a continuing source to the aquifer

Lab test and modeling ongoing to mend the In Situ Redox Manipulation Barrier; 2008 field demo planned. A 50-gpm test of Electrocoagulation technology was completed. Further pilot-scale tests and monitoring of *in situ* bioremediation show promise, with additional tests in 2008.

Impact

A systems approach using innovative technologies potentially can significantly reduce human health and environmental risks adjacent to the Columbia River, while expediting cleanup with lower life-cycle cost than current baseline technologies

Electrocoagulation Unit

Columbia River Projects: Treatment of Groundwater Containing Strontium-90

Challenge

Pump and treat remedy for strontium-90 in groundwater in 100-N Area adjacent to the Columbia River specified in the Record of Decision is not effective in preventing migration of the radionuclide into the river

Solution

A reactive barrier created by injecting phosphate solutions into wells can stabilize the strontium-90

Both groundwater and the source zone above the water table must be treated

Accomplishments

A 300-ft barrier was installed to treat groundwater, but a continuing source of radionuclides in the soils above the water table remained

Columbia River Project funded lab tests to treat the source zone above the water table and excellent results were obtained; field testing is needed

Impact

This passive barrier technology could potentially replace the pump and treat system, significantly reducing annual operating costs, saving millions in life-cycle costs and preventing strontium-90 from entering the river

100-N Area Location
for Reactive Barrier

Columbia River Projects: Treatment of Uranium in Groundwater

Challenge

The Natural Attenuation remedy for uranium in groundwater specified in the Record of Decision is not effective; an alternative groundwater treatment system should be deployed

Solution

A reactive barrier created by injection of polyphosphate solutions into wells to stabilize uranium

Both the groundwater and the soils above the water table where uranium exists as a continuing source to the aquifer must be treated

Accomplishments

A pilot-scale field test demonstrated proof-of-principle for creating a barrier, but high groundwater flow rate was problematic

Laboratory tests to treat uranium source material above the water table are ongoing

Impact

Passive barrier technology has the potential to save millions in life-cycle costs as compared to an active pump and treat system, which would be the primary alternative considered

Polyphosphate Injection Pilot Test

Columbia River Projects: Carbon Tetrachloride and Chloroform

Challenge

Large uncertainty in abiotic degradation rates limits the ability to predict fate and transport and to develop cost-effective remediation plans for carbon tetrachloride and chloroform in the 200 West Area at Hanford

Solution

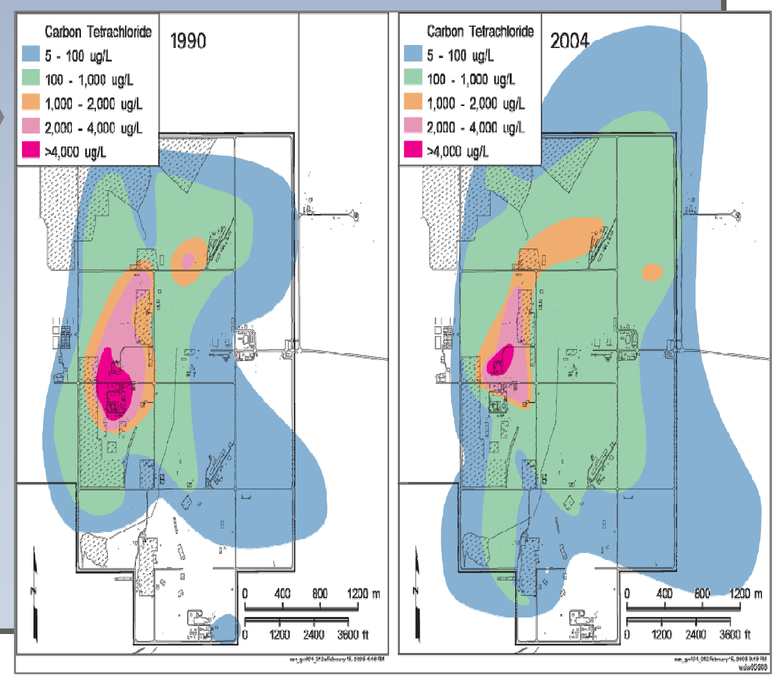
Laboratory studies will provide fundamental understanding of the fate and transport of these compounds at Hanford

Accomplishments

Critical physical-chemical data for carbon tetrachloride and chloroform hydrolysis reactions under Hanford groundwater conditions are being collected

Impact

The technical basis for decisions regarding remediation of these large organic contaminant groundwater plumes at Hanford will be substantially improved, resulting in potentially significant cost savings and schedule acceleration



Waste Processing

Fluidized Bed Steam Reforming-SRS

Challenge
240,000 gallons of highly radioactive liquid waste that contains 22,000 kgs of organic compounds, posing a flammability hazard, in Savannah River Tank 48, must be treated to destroy the organics, so it can be converted to service as a Salt Waste Processing feed preparation tank

Solution
Fluidized Bed Steam Reforming (FBSR) met all test requirements for organic destruction, the only alternative to do so after several were evaluated and tested

Accomplishments
3,300 gallons of waste simulant were treated on a 75% scale pilot plant to produce 6,900 pounds of granular solid

>99.9% of organics destroyed and all test conditions met

Off-gas samples were obtained for future testing

Impact
FBSR has been selected as the baseline technology for Savannah River Tank 48 Treatment

Fluidized Bed Steam Reforming-INL

Challenge

~1 million gallons of liquid sodium-bearing waste at Idaho National Laboratory must be solidified and packaged for shipment to the Waste Isolation Pilot Project or the High Level Waste (HLW) Repository, depending on results of waste determination

Solution

Fluidized Bed Steam Reforming can satisfy high level waste disposal performance requirements

Accomplishments

Fluidized Bed Steam Reforming bench-scale test at Savannah River National Laboratory demonstrated waste form resistant to leaching

Fluidized Bed Steam Reforming pilot-scale demonstration met system objectives, including environmental compliant off-gas component

Testing at Hazen Research Center in 2007 validated flowsheet as viable for Integrated Waste Treatment Unit at Idaho

Impact

Fluidized Bed Steam Reforming is currently under construction for treatment of sodium-bearing waste at Idaho National Laboratory

Fluidized Bed Steam Reforming test facility at Hazen Research in Colorado

Glass Formulation and Processing Challenges for High Level Waste (HLW)

Challenge

Improvements in glass formulations and processing could significantly reduce the number of canisters of vitrified glass to be produced

Solution

Improve glass formulation and processing targets by improving melting rates for high aluminum-containing wastes, determining effect of increasing the melter temperature, and determining effect of trace crystalline products on melter operations

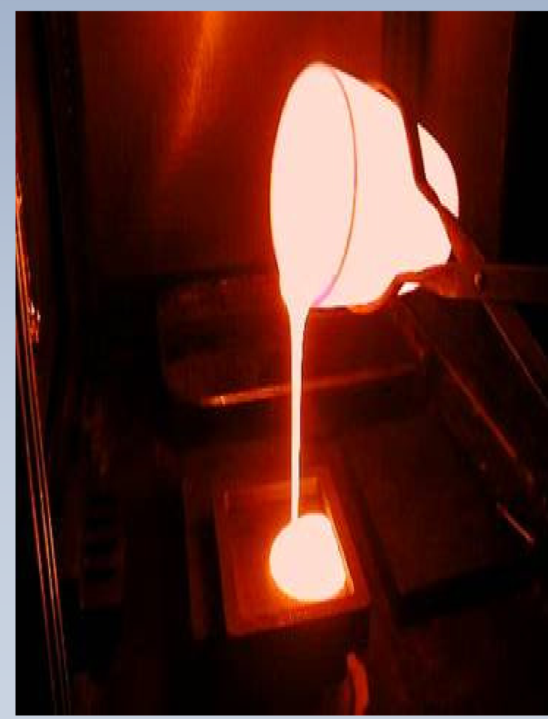
Accomplishments

Testing program initiated to develop and characterize High Level Waste glasses with higher waste loadings

Risks identified for High Level Waste production rate shortfall

Potential Impact

Increasing waste loading from 25 wt % to >33 wt % will potentially reduce the High Level Waste canister production requirement by 25% or more



Low-Temperature Caustic Leaching

Challenge

The mass of sludge in the Savannah River high-level waste (HLW) tanks is currently estimated to fill ~7,900 canisters when treated, which is more than previously estimated and likely will impact the Site Treatment Plan commitment to treat all high-level waste by 2028

Solution

In-tank, low-temperature caustic leaching to remove the aluminum in the sludge could significantly reduce the volume of waste required for vitrification

Accomplishments

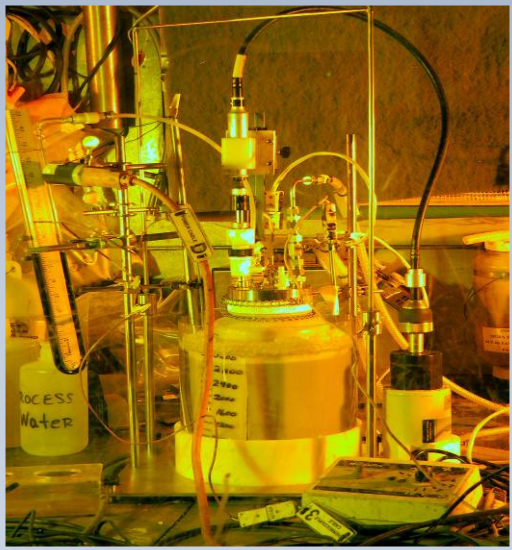
Low-temperature caustic leaching was recently demonstrated at full scale in Tank 51 at Savannah River

- 65% of the insoluble aluminum was removed
- No new equipment was required and dissolution was complete after 80 days
- The aluminum-rich decant stream is staged for feed to the Salt Waste Processing Facility

Impact

The aluminum removed reduced the sludge volume by the equivalent of 100 canisters, reducing the life-cycle cost of the Savannah River high-level waste mission by $40 million

This process may potentially reduce sludge mass by the equivalent of 900 canisters with a $900 million life-cycle cost reduction



Caustic Leach Test System

Small Column Ion Exchange (SCIX)

Challenge

To accelerate the processing of high-level (HLW) at Savannah River and Hanford, methods are needed to remove cesium, thus enabling appropriate separation

Solution

Small Column Ion Exchange (SCIX) deployed to augment the Savannah River Salt Waste Processing Facility, with resins developed and optimized for the SCIX process

Accomplishments

Crystalline silicotitanate: tested with Savannah River simulant and real waste in small-scale column; 30,000 gallons real waste processed at Oak Ridge National Laboratory in 10-gallon column

Resorcinol formaldehyde: 53 bed volumes tested with Hanford simulant; tested with Hanford real waste at Pacific Northwest National Laboratory; being adopted as the Baseline for Hanford Waste Treatment Plant

Decontaminated salt solution processed through either resin easily met Class A limits

Potential Impact

Small Column Ion Exchange may accelerate tank closure by decreasing the life-cycle associated with salt waste processing

The Small Column Ion Exchange equipment can be mounted in existing waste tank risers, reducing the shielding and construction costs, as well as disposal costs

Small Column Ion Exchange Test System

Fractional Crystallization

Challenge

Separation of high-level waste into a low-volume high-level waste stream and a high-volume low-activity waste stream could reduce the number of high-level waste glass canisters to be produced by the Hanford Waste Treatment Plant for offsite disposal

Solution

Fractional crystallization uses an evaporation and crystallization process to separate most of the radioactive isotopes (e.g., cesium, technetium, and iodine) from the nitrate and nitrite salts that make up a large part of the waste in Hanford's high-level waste tanks

Accomplishments

The technology is well proven in industrial applications, generates very little secondary waste, and has been demonstrated to produce the required separation results

After successful lab- and engineering-scale testing, a pilot plant, currently under construction at Savannah River National Laboratory, will be operated in 2008 to test Hanford waste

Potential Impact

Fractional crystallization, as a pretreatment technology, may support an early low activity waste vitrification start-up or other supplemental treatment, such as Bulk Vitrification, thus potentially reducing the Waste Treatment Plant schedule by up to 20-30 years and potentially saving >$1B

Rotary Microfilter

Challenge

During processing of high-level waste (HLW) at Savannah River and Hanford, solid-liquid separation, requiring a large footprint, is often rate limiting, thus impacting the overall high-level waste treatment schedule

Solution

A rotary microfilter is being developed and tested to perform the solid-liquid separation step needed for these treatment processes

Accomplishments

A 3-disk commercial unit was tested for 4,000 hours with Savannah River simulated sludge

A full-scale, 25-disk prototype was tested with Savannah River simulated sludge

A smaller commercial unit was demonstrated with Savannah River real waste sludge

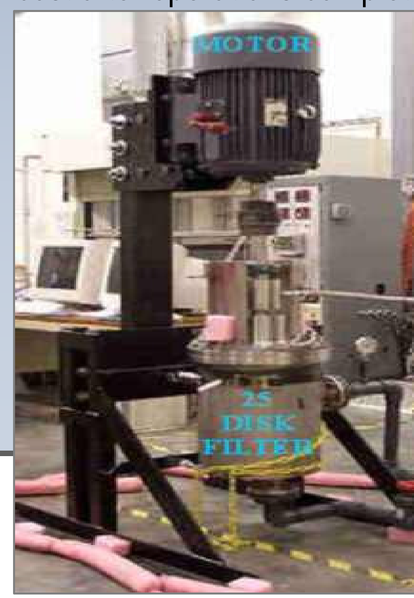
Design drawings for deployment in Savannah River tank risers were completed

Additional testing underway for Hanford application

Potential Impact

Rotary microfilter potentially will allow Savannah River and Hanford to treat additional radioactive liquid waste for processes such as Small Column Ion Exchange, Supplemental Pretreatment, Bulk Vitrification, and Sludge Washing, accelerating tank closure

The rotary microfilter can be placed in a waste tank riser, thus reducing shielding and construction costs, as well as lower disposal cost after operations completed



Fluidic Systems for Waste Retrieval and Sampling

Challenge

Improved tank waste retrieval technologies are necessary to enable schedule acceleration and reduced costs, while minimizing worker safety risk

Solution

Power Fluidics Technology

- Maintenance-free with no moving parts in contact with the radioactive waste
- Single system deployment for waste retrieval and tank closure
- Water recycle to reduce secondary wastes

Accomplishments

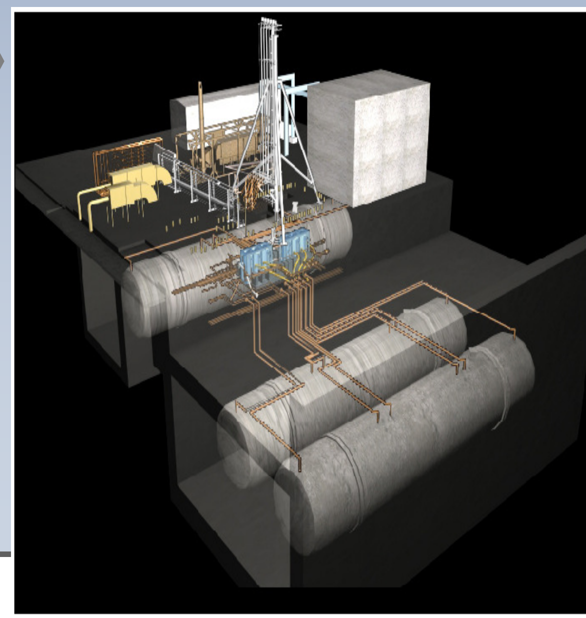
Proven technology from the United Kingdom

Multiple (>25) full-scale deployments at Department of Energy sites since 1997

Impact

DOE deployments have solved intractable problems, shown improvements to worker safety and schedule acceleration, and realized significant cost savings

More opportunities for deployments and future benefits at the Hanford and Savannah River tank farms



Soils and Groundwater

Electrical Resistance Heating (ERH)

Challenge

The slow release of industrial solvents trapped in clay layers can extend the timeframe for cleanup by 10s or even 100s of years

Solution

The DOE Environmental Management program funded development of electrical resistance heating (ERH) to speed up the release and removal of solvent contamination from clay layers

Technology developers included researchers from Pacific Northwest National Laboratory and scientists with backgrounds in enhanced oil recovery

Accomplishments

Electrical resistance heating first field demonstrated at the Savannah River Site

Electrical resistance heating patented and commercialized and now being applied by multiple vendors

Applications are now supported by regulatory guidance documents, multiple case studies, and support of multiple federal agencies

Impact

The DOE-developed technology is seeing widespread application within the private sector and for government projects, saving money and significantly accelerating cleanup schedules

Paducah Gaseous Diffusion Plant (KY) – electrical resistance heating being designed to treat subsurface

Carbon Tetrachloride Conceptual Model

Challenge

Remediation of carbon tetrachloride present in groundwater over an area of 11 square kilometers In the 200 Area at Hanford must address contaminant sources above the water table

Solution

A conceptual model of carbon tetrachloride sources was developed and tested to provide an improved understanding of the location and extent of the source material

Accomplishments

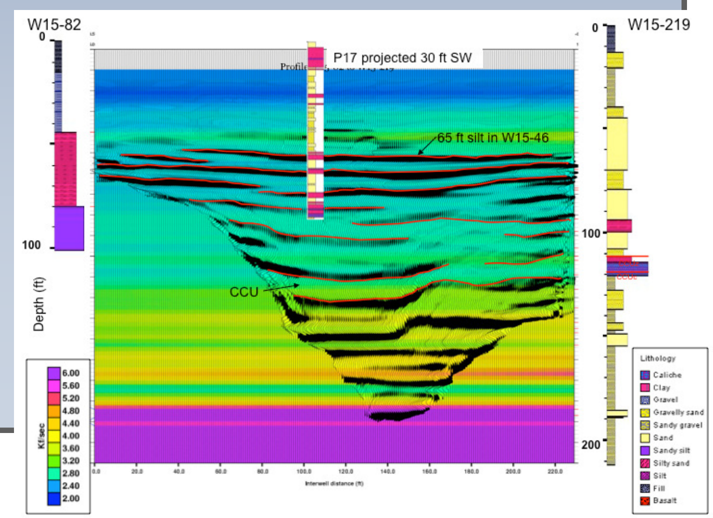
A prompt evaporation model provided key insight into disposal practices

The lateral extent of the source region was confirmed using geophysical (seismic) methods

Updated source inventory calculations, based upon field vapor-phase measurements, reduced the unaccounted for inventory to between 21 and 40%

Potential Impact

Refinements to the understanding of the quantity of source material present in the unsaturated zone near the Z-9 Trench at Hanford may enable a more effective and efficient remedial approach, thus accelerating cleanup schedules and reducing costs



Monitored Natural Attenuation/Enhanced Attenuation for Chlorinated Solvents

Challenge

Address fundamental challenges in reaching final closure for many DOE sites with contaminated soils and groundwater: transitioning costly source treatments and developing regulatory support

Solution

Technical guidance, tools, and collaboration with state regulators to promote acceptance of natural attenuation/enhanced attenuation

Accomplishments

New technologies and tools were developed and demonstrated to promote acceptance of attenuation-based remedies for chlorinated solvents

Developed guidance with state and federal regulators for implementing technical products within regulatory frameworks and implemented web-based training on technical advances

Impact

Technical developments enable transition from active, energy-intensive treatments to "green" treatments, minimizing our energy footprint on a national scale, while also saving money

Publicly available training is resulting in technical advancements in the public/private sectors

Retrieval of Passive Flux Monitor

Push-Pull Test

Attenuation-based Remedies for Metals and Radionuclides

Challenge
Environmental clean-up strategies at sites with metals and radionuclides often leave the contaminants in place, but they can pose a risk for 1000s of years

Solution
Attenuation-based remedies can be implemented to demonstrate reduced risk through development of technical guidance and tools

Accomplishments
Research to further understand natural attenuation processes in the subsurface is being conducted collaboratively by Savannah River and Lawrence Berkeley National Laboratories with extensive communications with the Environmental Protection Agency and state regulators

Impact
Sustainable, low-energy approaches to cleaning up metals and rad-contaminated sites will minimize risk receptors

Training in new technical developments and approaches will be made available first to DOE and to the broad stakeholder community

Lawrence Berkeley researcher viewing soil samples from site

Savannah River scientist collecting water samples from wetlands

Decontamination and Decommissioning

New Non-Destructive Assay and Examination Technologies

Challenge

Transuranic (TRU) contaminated materials must be characterized before they can be shipped for long-term disposal at the Waste Isolation Pilot Plant (WIPP) in New Mexico; containers must be opened, examined, and repackaged, resulting in radiation exposure, and adds significant cost and schedule

Solution

Innovative non-destructive assay and evaluation technologies that meet WIPP criteria:

Non-Destructive Assay: Gamma Assay Module directly determines mass of gamma-emitting contaminants, and isotopic composition of the waste

Non-Destructive Examination: a robotic-controlled heavy-material handling system to detect presence of liquid and aerosol containers

Accomplishments

These new Non-destructive Assay and Examination technologies have demonstrated effective waste characterization without opening of transuranic waste containers

Impact

The new **Non-Destructive Assay and Examination Technologies** will enable shipment of large transuranic waste containers without repackaging, greatly reducing hazards to workers, while reducing shipping costs of $600M-$900M and saving 8-12 years in schedule

Chemical Decontamination of Glove Boxes and Tanks

Challenge
The glove boxes and tanks at Rocky Flats had to be size-reduced to meet the waste acceptance criteria for transportation and disposal of transuranic (TRU) waste at the Waste Isolation Pilot Plant (WIPP), but size reduction is a labor-intensive, hazardous activity for site workers

Solution
Cerium nitrate can be used to decontaminate the interior surfaces of glove boxes and tanks to remove virtually all the plutonium contamination and enable classification as low–level waste

Accomplishments
Cerium nitrate was used to clean the contaminated surfaces of glove boxes and tanks so they could be disposed of as low level waste at the Nevada Test Site or commercial disposal sites

Impact
Due to the cerium nitrate decontamination technology, Rocky Flats reduced the amount of transuranic waste that was shipped to the Waste Isolation Pilot Plant by 30% or 5,000 cubic meters

Worker exposure to high airborne radioactivity was significantly reduced and industrial hazards associated with size reduction of glove boxes and tanks was eliminated

Disposal costs for an average size glove box were reduced from approximately $140K to $6.5K

Foam Encapsulation of Leaded Glove Boxes

Challenge

More than 1,300 glove boxes that contained leaded gloves, glass, and flashing and were contaminated with plutonium, uranium, and americium needed be disposed of to successfully close the Rocky Flats Site. To meet waste disposal criteria required for shipment of the glove boxes as low level waste, workers were required to conduct high-hazard and labor-intensive activities.

Solution

DOE worked with the Instacote™ Company to develop a spray foam, called BASF Autofroth™, for stabilizing contamination inside the glove boxes and macro-encapsulating lead-bearing materials to meet the requirements of the nuclear regulation 1608

Accomplishments

Rocky Flats was able to dispose of all glove boxes without manually removing all leaded components

Impact

Foam encapsulation enabled all the Rocky Flats glove boxes to be disposed of at the Envirocare facility in Utah

Without foam encapsulation, significant delays would have occurred in site closure, with attendant cost increases

Foam encapsulation also reduced risk to workers who would have had to remove all lead prior to disposal

Robotic Technology

Challenge

Deactivation and Decommissioning activities require remote handling due to high doses of radiation that workers would be subjected to perform the required tasks

Solution

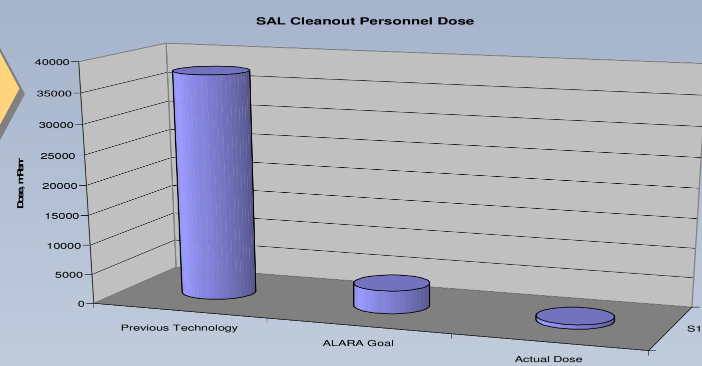
Transfer of previously developed robotic platforms built for glove box size-reduction

Accomplishments

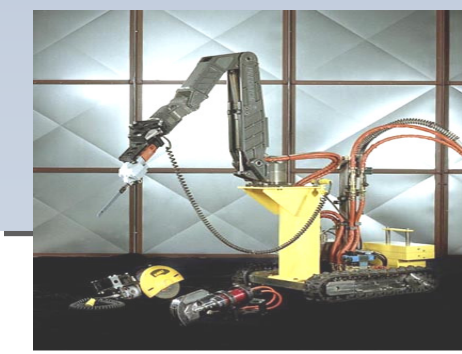
A robotic platform built for glove box size-reduction at Rocky Flats was used to clean out a hot cell in the Shielded Analytical Laboratory in the 325 building at Hanford, after coordination between staff at Hanford, Rocky Flats, Pacific Northwest National Laboratory, and Environmental Management Headquarters

Impact

Overall dose to staff performing the various cleanup tasks was significantly reduced from an estimated 37,550 milli-rem (m-r) down to a little more than 715 m-r



Dose Reduction



Technology Development and Deployment Strategic Initiatives laid out in the Environmental Management Engineering and Technology Roadmap (March 2008)

- **Waste Processing**
  - Improved Waste Storage
  - Reliable and Efficient Waste Retrieval
  - Enhance Tank Closure Processes
  - Next-Generation Pretreatment Solutions
  - Enhanced Stabilization
  - Spent Nuclear Fuel: Improved Storage, Stabilization and Disposal preparation
  - Challenging Materials: Enhanced Storage, Monitoring and Stabilization Systems

- **Groundwater and Soil**
  - Improved Sampling and Characterization Strategies
  - Advanced Predictive Capabilities
  - Enhanced Remediation Methods

- **Deactivation and Decommissioning (D&D)**
  - Characterization
  - Deactivation, Decontamination, and Demolition
  - Closure

Strategic Planning Approach for Engineering and Technology Program Activities

- Implementation of Roadmap Initiatives
- Critical, High-Risk, High-Payoff Projects that address needs identified by Federal Project Directors
- Technical Workshops and Exchanges to share information and lessons learned
- External Technical Reviews and Site Risk Management Plans to develop technical solutions
- Technology Readiness Assessments to focus investments in technologies to support first-of-a kind applications
- Coordination across Complex via HLW Corporate Board
- Competitive solicitations to private sector, universities, and national laboratories.
- Peer reviews and/or project reviews for new and ongoing projects prior to selection and at key points in the project development.

Leverage Research Investments

- Leverage investments made within the Department by Office of Science, Office of Nuclear Energy, National Nuclear Security Administration, and Office of Civilian and Radioactive Waste, especially in the areas of predicting high level waste performance and characterization of radiological waste.

- Leverage investments made by other federal agencies such as Department of Defense (e.g., Strategic Environmental Research and Development Program), Department of Homeland Security (e.g., radiation detection) and National Institute of Standards and Technology.

- Continue to work cooperatively with Nuclear Regulatory Commission on issues such as long term performance of cementitious materials.

- Continue to work cooperatively with the United Kingdom Nuclear Decommissioning Authority to share lessons learned for cleanup activities and to conduct joint Technology Readiness Assessments to evaluate technologies being developed and implemented in the United Kingdom.

National Research Council of the National Academy of Sciences' Interim Report: Technical and Strategic Advice on Office of Environmental Management's Development of a Cleanup Engineering and Technology Roadmap

Observations

- The complexity and enormity of EM's cleanup task require the results from a significant, ongoing R&D program so that EM can complete its cleanup mission safely, cost effectively, and expeditiously.
- By identifying the highest cost and/or risk aspects of the site cleanup program, the EM roadmap can be an important tool for guiding DOE headquarters investments in longer term R&D to support efficient and safe cleanup.
- The national laboratories at each site have special capabilities and infrastructure in science and technology that are needed to address EM's longer-term site cleanup needs. The EM roadmap can help establish a more direct coupling of the national laboratories' capabilities and infrastructure with EM's needs.

Conclusions

- The committee generally agrees with the five program areas for strategic R&D presented in EM's draft Cleanup Technology Roadmap.
- According to the range of technology needs presented to the committee and the committee's initial observations, the committee judges that existing knowledge and technologies are inadequate for EM to meet all of its cleanup responsibilities in a safe, timely, and cost-effective way. Meeting current and future EM challenges will require the results of a significant, ongoing R&D program.
- The committee is concerned that the medium- and long-term research component of EM's program has largely disappeared. Implementing the roadmap will require substantial and continuing federal support for medium- and long-term R&D for technologies focused on high priority cleanup problems.

Roadmap Development

- Input provided by EM Federal Project Directors, Stakeholders, Contractors, National Laboratories, and the National Academy of Science

- Identified technology risks in Waste Processing, Groundwater and Soil Remediation, and Deactivation & Decommissioning/Facility Engineering, Spent Nuclear Fuel, Roadmap identifies technical risks and uncertainties in EM program over next ten years
- Challenging Materials, and Integration

- Establishes strategic initiatives to address technical risks and identifies expected outcomes when implemented

Waste Processing
Risks & Strategic Initiatives

Technical Risk and Uncertainty

Waste Storage

- Existing tanks provide limited storage and processing capacity, have exceeded their original design life, and will likely be in service for extended periods of time.
- Conservative assumptions regarding behavior of waste during storage, such as flammable gas generation, restrict operations and increase costs.

Waste Retrieval

- Current waste removal and retrieval operations and monitoring technologies are costly, sometimes inefficient, and are limited by complicated internal tank design (e.g., obstructions) and conditions (e.g., past leak sites).

Tank Closure

- Achieving lower levels of residual radioactivity and improving immobilization of residual materials might be possible if there were more cost-effective and efficient closure methods for some tanks.
- Final closure of some waste management areas, including closure of ancillary equipment such as underground transfer lines and valve boxes, would be facilitated by improved closure methods that would make the process more cost-effective and efficient.

Waste Pretreatment

- Achieving effective separation of low- and high-level wastes (HLW) prior to stabilization requires improved, engineered waste processes and a more thorough understanding of chemical behavior.

Stabilization

- Waste loading (i.e., the amount of waste concentrated in waste containers) constraints limit the rate that HLW can be vitrified and the tanks can be closed.
- Current vitrification techniques may require supplemental pretreatment to meet facility constraints.

Strategic Initiatives

Improved Waste Storage Technology

- Develop cost-effective, real-time monitoring of tank integrity and waste volumes to ensure safe storage and maximum storage capacity.
- Improve understanding of corrosion and changing waste chemistry, including flammable gas generation, retention, release, and behavior to establish appropriate assumptions in safety analyses.

Reliable & Efficient Waste Retrieval Technologies

- Develop optimization strategies and technologies for waste retrieval that lead to successful processing and tank closure.
- Develop a suite of demonstrated cleaning technologies that can be readily deployed throughout the complex to achieve required levels of removal.

Enhanced Tank Closure Processes

- Improve methods for characterization and stabilization of residual materials.
- Develop cost-effective and improved materials (i.e., grouts) and technologies to efficiently close complicated ancillary systems.
- Perform integrated cleaning, closure, and capping demonstrations.

Next-Generation Pretreatment Solutions

- Develop in- or at-tank separations solutions for varying tank compositions and configurations.
- Improve methods for separation to minimize the amount of waste processed as HLW.

Enhanced Stabilization Technologies

- Develop next-generation stabilization technologies to facilitate improved operations and cost.
- Develop advanced glass formulations that simultaneously maximize loading and throughput.
- Develop supplemental treatment technologies.

Groundwater & Soil Remediation Risks & Strategic Initiatives

Technical Risk and Uncertainty

Sampling and Characterization

- Current sampling techniques and characterization technologies result in costly, time-consuming characterization programs, may leave large gaps in plume delineation, and may lead to uncertainty in the selection of cleanup strategies.
- Incomplete understanding of contaminant subsurface behavior results in long-term uncertainty regarding risks to human health and the environment.

Modeling to Guide Cleanup

- Existing models provided limited capability to represent complex hydrogeology, biogeochemistry, chemical reactions, and transport. Improved models are needed to reduce risk and uncertainty in predicting contaminant fate and transport and to provide an improved technical basis for optimizing the selection, design and implementation of remedies.

Treatment and Remediation

- In-situ treatment and stabilization technologies provide cost, human health and ecological benefits, but require additional development and demonstration to realize their full potential and to be accepted by the regulatory community.
- Ex-situ technologies may be necessary to remove, treat, isolate and dispose of contaminants in certain situations, but current ex-situ treatment technologies may result in high cleanup costs and unacceptable risks to workers.

Strategic Initiatives

Improved Sampling and Characterization Strategies

- Develop advanced sampling and characterization technologies and strategies for multiple contaminants (organics, metals and radionuclides) in challenging environments (e.g., around subsurface interferences, at intermediate and great depths, and in low and high permeability zones.
- Use basic and applied research to gain a better understanding of contaminant behavior in the subsurface and to provide defensible prediction of risk.

Advanced Predictive Capabilities

- Develop advanced models that incorporate chemical reactions, complex geologic features, and/or multiphase transport for multiple contaminants (organics, metals and radionuclides) in challenging environments to provide an improved technical basis for selecting and implementing remedies.
- Determine mechanisms and rates of release of contaminants from low porosity/permeability zones.
- Develop models that integrate data from various monitoring forms to design long-term effective monitoring systems.

Enhanced Remediation Methods

- Develop, demonstrate and implement advanced in-situ and ex-situ methods which reduce costs, increase effectiveness and reduce risks to human health and the environment.
- Improve understanding of in-situ degradation of chlorinated organics and immobilization of radionuclides and metals to facilitate development and use of advanced, cost-effective in-situ technologies and use of natural processes.
- Provide the technical basis for use of monitored natural attenuation (MNA) of organics, radionuclides, and metals in the subsurface, including use of MNA in conjunction with other methods (e.g., barrier technology).
- Develop safe, cost-effective strategies to treat and remediate legacy materials in historical waste sites, as appropriate.

D&D/Facility Engineering
Risks and Strategic Initiatives

Technical Risk and Uncertainty

Characterization

- Limited techniques for detection, quantification and localization of penetrating radiation, radioactive contamination (e.g., Pu, U, tritium), chemicals (asbestos, beryllium, metals, organics, caustic and acidic solutions, lead paint), and biological contaminants (mold, dead birds and rodents, and animal feces) increase the risk of personnel exposure to hazardous conditions.

Deactivation, Decontamination, and Demolition

- Hazardous conditions involving radionuclides, heavy metals, and organic contaminants result in worker safety issues and lead to use of cumbersome personal protective equipment and D&D approaches.
- Inadequate historical knowledge of past operations and contamination (and other hazards) drive conservative and costly D&D approaches.

Closure

- End-state requirements for D&D of process facilities are not adequately defined.

Strategic Initiatives

Adapted Technologies for Site-Specific and Complex-Wide D&D Applications

- Develop and deploy improved characterization and monitoring technologies for detecting and quantifying penetrating radiation, radioactive, and biological contaminants.
- Develop and deploy improved deactivation, retrieval, size-reduction, and stabilization technologies that provide adequate personal protection and effectively achieve end-state requirements.
- Develop and deploy advanced remote and robotic methods to rapidly access and assay facilities to determine optimal D&D approach.
- Establish the scientific and technical basis for end-state conditions to satisfy federal, state, and local stakeholders.

DOE Spent Nuclear Fuel (SNF) Risks and Strategic Initiatives

Technical Risk and Uncertainty

Spent Fuel Storage

- Storage of vulnerable SNF types (e.g., aluminum-clad) and conditions (SNF and basins) are subject to continued deterioration, and may impact repository acceptance.

Spent Fuel Stabilization

- Present facilities and methods are not designed for processing all SNF types.

Disposal Packaging Preparation

- Geologic disposal of SNF requires assurance of criticality control over long timeframes.
- Current plans identify the need for a canister closure weld in a high radiation environment for which commercial systems do not exist.

Strategic Initiatives

Improved SNF Storage, Stabilization and Disposal Preparation

- Improve monitoring of fuel condition, cladding integrity, and basin integrity.
- Develop efficient, cost-effective stabilization technologies and processes based on spent fuel types.
- Develop advanced neutron absorber materials for use inside disposal packages to meet long-term criticality control needs.

Challenging Materials
Risks and Strategic Initiatives

Technical Risk and Uncertainty

Storage

- Improved inventory analyses, monitoring and storage systems are needed for unique TRU wastes and special nuclear materials.

Stabilization and Disposition

- Some materials have no defined path for disposal in their current condition.

Strategic Initiatives

Enhanced Storage, Monitoring and Stabilization Systems

- Develop advanced characterization, monitoring, and inventory analysis methods; and improved storage systems for multiple material forms including contaminants.
- Develop advanced processes for stabilization and waste form qualification.

Integration & Cross-Cutting Risks and Strategic Initiatives

Technical Risk and Uncertainty

Assessing Long-Term Performance

- Inadequate fundamental understanding of wasteform performance and contaminant release, transport, and transformation processes result in inadequate conceptual models potentially leading to selection and design of non-optimal remedial actions.
- Inadequate long-term monitoring and maintenance strategies and technologies to verify cleanup performance could potentially invalidate the selected remedy and escalate cleanup costs.

Transportation and Disposal Packaging

- Disposal and transportation restrictions include flammable gas limitations, material characteristics and configuration. Existing data is insufficient to quantify the effects of potential sources of hydrogen, deflagration events, degraded fuel, impurities, and other conditions for challenging materials.

Strategic Initiatives

Enhanced Long-Term Performance Evaluation and Monitoring

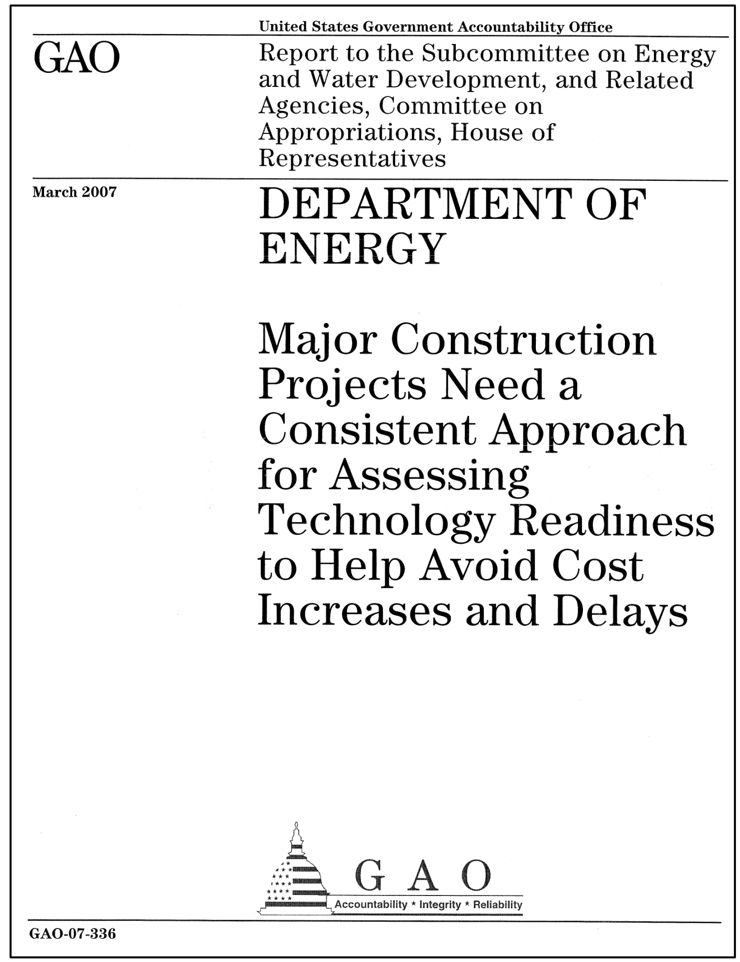
- Develop increased understanding of long-term wasteform performance integrated with transport of contaminants to support broad remedial action decisions and cost-effective design and operation strategies.
- Develop and deploy cost-effective long-term strategies and technologies to monitor closure sites (including soil, groundwater, and surface water) with multiple contaminants (organics, metals and radionuclides) to verify integrated long-term cleanup performance.

Improved Packaging of SNF, TRU Waste and Nuclear Materials

- Develop improved packaging and conduct tests and/or analyses to meet regulatory requirements.
- Improve inventory and characterization data.

Background for DOE TRAs

- **GAO initiated review of DOE projects in 2006 to assess relationship between technology maturity and project cost growth and schedule extension**
  - 12 DOE projects reviewed-WTP included
  - Concluded that implementing immature technology in design was part of the reason for cost growth
  - Recommended that DOE use a consistent process for measuring readiness of critical technologies
  - DOE supports GAO's recommendation and suggested a pilot application to understand process
- **In late 2006 DOE initiated 3 TRAs**
  - WTP Used as Pilot Case



United States Government Accountability Office

GAO

Report to the Subcommittee on Energy and Water Development, and Related Agencies, Committee on Appropriations, House of Representatives

March 2007

DEPARTMENT OF ENERGY

Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays

G A O

Accountability * Integrity * Reliability

GAO-07-336

Technology Readiness Assessments (TRAs)

- **A description of what has been done to develop a technology at a given point in time (i.e., not a "grade").**
- **An systematic evaluation of a technology in terms of Technology Readiness Levels (1-9).**
- **For a given system, subsystem or element, the TRL for the whole equals the lowest TRL of its components.**

Why Conduct a TRA?

- A useful project management tool to support design/ construction project management decisions, reduce technical risk—and thereby—limit costs and schedule overruns
- A consistent, systematic and structured process to evaluate & communicate the status of technology development
- An emerging standard for Federal Projects
  - Originally developed by NASA
  - Congressionally mandated for DoD
  - Recommended for DOE use by GAO (GAO-07-336)
- International use - U. K. Nuclear Decommissioning Authority, Australian Defense Department

TRA Methodology

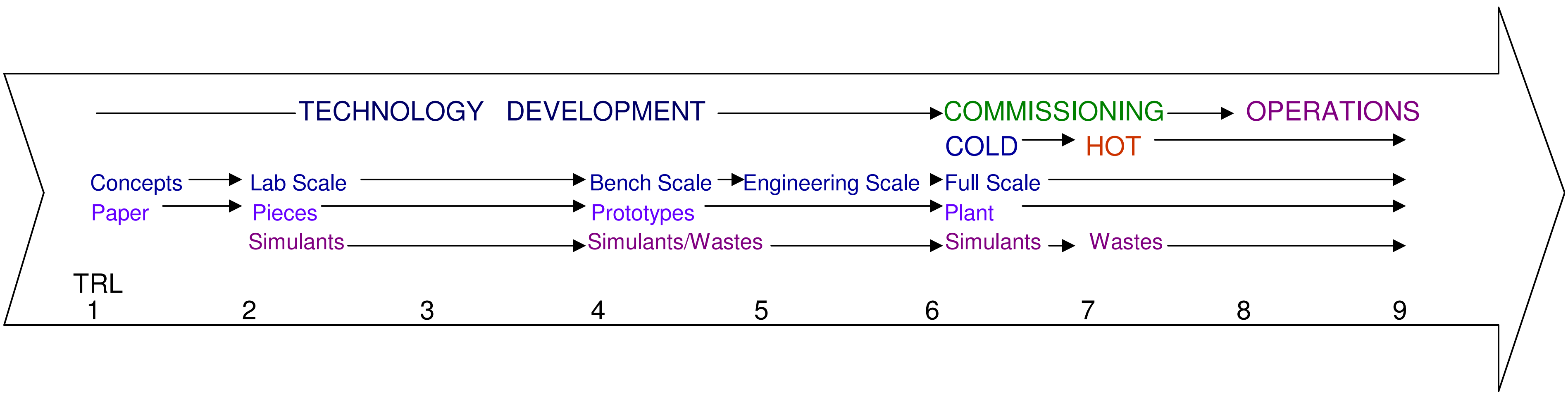
- **Based upon *Department of Defense, Technology Readiness Assessment (TRA) Handbook*, May 2005**
- **TRA Steps**
  1. **Identify Critical Technology Elements (CTEs)**
  2. **Determine TRL for each CTE**
  3. **Prepare a Technology Maturation Plan (TMP) for technologies with TRLs below desired level**
- **Incorporation of TRA/TMP insights into project plans and schedules**

Technology Readiness Level Scale

Stage	TRL	Description
System Operations	TRL 9	Actual equipment/process successfully operated in the operational environment (Hot Operations)
System Commissioning	TRL 8	Actual equipment/process successfully operated in a limited operational environment (Hot Commissioning)
	TRL 7	Actual equipment system/process system successfully operated in the expected operational environment (Cold Commissioning)
Technology Demonstration	TRL 6	*Prototypical equipment/process system demonstrated in a relevant environment (Cold Engineering Scale Pilot Plant)*
Technology Development	TRL 5	Bench scale equipment/process system demonstrated in a relevant environment
	TRL 4	Laboratory testing of similar equipment systems completed in a simulated environment.
Research to Prove Feasibility	TRL 3	Equipment and Process analysis and proof of concept demonstrated in a simulated environment
Basic Technology Research	TRL 2	Equipment and process concept formulated
	TRL 1	Basic process technology principles observed and reported

TRL 6 normally required for incorporation of technology into design

DOE Technology Readiness Levels



Pilot TRAs

DOE-EM has conducted 8 pilot TRAs

- **Hanford Waste Treatment and Immobilization Plant (WTP) Laboratory, Low Activity Waste (LAW) Facility and Balance of Facilities (BOF)**
- **Hanford WTP High-Level Waste (HLW) Facility**
- **Hanford WTP Pre-Treatment (PT) Facility**
- **Hanford Study of LAW Treatment Alternatives**
- **Hanford K Basins Sludge Treatment**
- **Savannah River Tank 48H Waste Treatment Technologies**

Conclusions

- Roadmap identifies strategies to reduce risks and improve technologies and processes at EM sites.
- External Technical Reviews have been proven useful in supporting critical project management decisions.
- Project Risk Management Plans should be used to help resolve technical risks and uncertainties.
- Technology Readiness Assessments are a promising tool to delineate technical risk. Technology Maturity Plans are key to reducing project risk.
- Better communication is needed to ensure project success.